

## STUDY ON TENSILE CHARACTERISTICS OF BASIC FLUX COATED ELECTRODE FOR MANUAL METAL ARC WELDING

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### **ABSTRACT**

*Manual metal arc welding is a common type welding which is used everywhere in fabrication industries. The flux uses for electrode has a vital role in its tensile strength characteristics besides its main function. This work focus on the effect of basic flux coated electrodes in weld strength. The fifteen type basic flux coated electrode are manufactured and used for MMAW. Flux with BI of 3.38 is shown maximum tensile strength of 740N/mm<sup>2</sup>. Tensile strength is improved with basicity index of flux. BI plays important role in the achieving even better mechanical properties.*

**KEYWORDS:** *Manual Metal Arc Welding (MMAW), Basicity Index (BI), Tensile Strength*

### **INTRODUCTION**

In both heavy and small industries, welding in the manufacturing, repairing, and restoration of components and systems are commonly used by metalworkers. Although there are many methods for joining metals, welding is one of the simplest and quickest methods available. A welded joint is accomplished by connecting two clean surfaces and using either pressure or heat or both for the bond. A basic foundation of welding is the ability of atoms to bind. In any welding process, the interdiffusion between the joined materials is the fundamental principle. The creation of metallic contacts and a perfect connection establishing in welding the metallic materials. As previously pointed out any welding process involves some energy, usually heat, to attach both materials. In two situations where only the heat or pressure alone was applied, the relative heat and pressure requirements for joining two materials would differ greatly. If heat is used for the construction of the joint alone the friction is essentially used to hold the joiners together. Examples of this process include SMAW, GTAW, and Submerged Arc Welding (SAW), etc. Examples of this process are Shielded Metal Arc Welding. Other types of welding are used, such as pressure and flame, resistance welding, friction welding, etc. In commercial welding activity, the electrical arc is by far the most common source of heat [1]. The SMAW arc welding method is the oldest arc welding procedure of the different arc welding processes.

SMAW is widely used for the processing, manufacture and repair of different parts. The quantity of current that can be used has a realistic limit. In the area of erection, restoration and reconstruction, SMAW is also used. SMAW is known for the efficient deposition of high-quality welding. However, it is slower and reliant more on operator experience in high-quality welds. The aim is to achieve the optimum balance of strength and durability for the welded joints. The microstructure has a good impact on both strength and toughness [2]. However, a sudden metal micro-structure with the strength comparable to base steel can be obtained by optimum selection of the welding current and speed. The various types of weld joint that can

be used in this process are various. Every joint has different strengths and uses, and so it is necessary to use the right one for the right work. When a butt weld joint is used for two bits of metal joined end to end. Butt joints are also used because you want a smooth face. Rohit and Jha studied the impact of welding variables on strength of welded joint and they found that the as the current at 120A, the maximum tensile strength obtained. The ultimate tensile strength (UTS) was 515.185 MPa. So it can be concluded that with the increase in welding current the UTS will increase until an optimum value. Increasing the current beyond this optimum value will result in decreasing UTS. Mattoo and Kumar (2015) performed an experimental study to investigate the effect of using different filler rods via Shielded Metal Arc Welding. The filler rods used in this work are austenitic stainless steel, ferritic stainless steel, and mild steel. The different welded samples have been tested and similar significant parameters like Tensile Strength and Brinell Hardness Number have been determined in order to be compared with the standards. They found that the tensile strength was a maximum when the Mild Steel 7018-filler rod was used and a maximum hardness was achieved when ferritic stainless steel 430-filler rod was used. Abdulzara, (2011) used steel alloy instead of carbon steel for achieving of engineering industry requirements. Whereas in carbon steel, a tensile strength higher than 700 MPa with a suitable toughness and ductility cannot be recorded. It is also susceptible to mass effect and the low resistance to corrosion and oxidation etc. The manual metal arc welding of low alloy high strength steel were done using some of electrodes, which are different in their chemical composition and price as well as testing their effects on tensile strengths. He showed that the tensile strength and the weld joint efficiency increased when iron powder low hydrogen covering electrodes were used. The tensile strength was (484MPa) and the weld joint efficiency was (56.9%), when (OK 48.04) electrode was used. Also, the tensile strength increased to (720MPa) and the weld joint efficiency was increased to (84.7%), when (OK 76.18) electrode was used. Ogbunnaoffor et al., (2016) investigated the effect of welding current on the structure, tensile properties, and performance of mild steel weld joints. Mild steel plate (AISI 1018) having 4mm thickness was used as a base metal for preparing butt-weld joints. The MMAW process was employed by using a 2.5mm diameter welding electrodes E6011 and E6013. E6011 produced a maximum yield strength and ultimate tensile strength values of 358.50 MPa, 421.70MPa respectively, while E6013 gave a maximum ultimate tensile strength and a yield strength values of 383.20 MPa and 319.37 MPa respectively. The best combination of the tensile properties tested for weldments was found when the electrode was made of E6011 and E6013 and then percentage elongation of the base metal is lower than that of the weld joints. Djukic, (2014) studied hydrogen embrittlement (HE). of steels is extremely interesting topic in many industrial applications. The specific mechanism of hydrogen embrittlement is manifested, depending on the experimental conditions investigation. The results presented in this paper, indicate the simultaneous action of the hydrogen-enhanced decohesion HEDE. and hydrogen enhanced localized plasticity HELP. mechanisms of HE, depending on the local concentration of hydrogen in investigated steel. Simultaneous effect is responsible for the decline in ductility.

## EXPERIMENTAL WORK

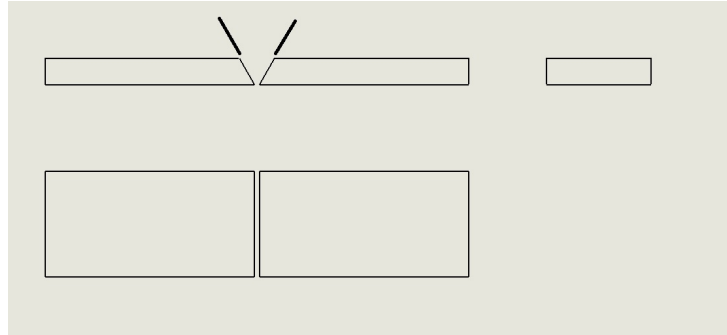
### Materials

In this work, High strength steel plates (ASTM 514) having a thickness of 10mm (3/8 in) is used as a base metal for the experimental work. It is widely used in pressure vessels, tanks, and pipeline for petroleum industries.

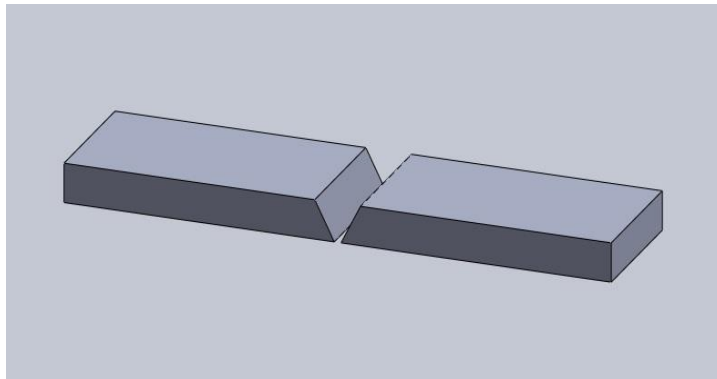
### Preparation of the Specimens

Tensile test specimens are prepared according to ASTM standard (E8/E8M-9) as shows in the Fig.2. Fifteen pieces of carbon steel plates have been prepared and machined as per ASTM dimensions. Single –V-groove butt joint with 3 mm

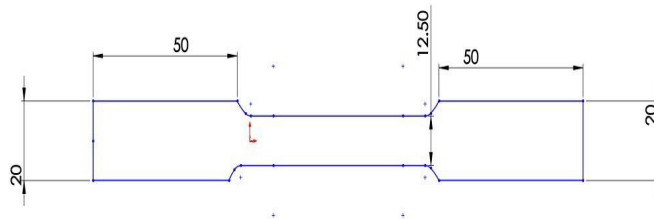
root face and angle of  $75^{\circ}$  with 2 mm opening was prepared to fabricate the MMAW welded joints as shown in Figure. The preparation of all welding joint edges was done by welding machine. The welding process was carried out using (MMAW) machine.



**Figure 1: Orthographic Projection of Plate To Be Welded.**



**Figure 2: 3D Model of Plate To Be Welded.**



**Figure 3: ASTM (E8/E8M-9) Standard Tensile Test Specimen.**

### Tension Test

Specimens in the form of rectangular bars of 12.5 mm width and 50 mm gauge length prepared on laser cutting machine were used to evaluate the tensile properties. The specimens for measuring tensile strength, yield strength and elongation were prepared from the welded joints as per the standard specification shown in Figure 4. Tensile strength test was performed on A514 steel and weld joint using tensometer as per the specimen orientation and size as per standard shown in Figure 5.



**Figure 4: Universal Tensile Testing Machine.**



**Figure 5: Tensile Specimen Before and After Test.**

## RESULTS AND DISCUSSIONS

From the results, the following can be concluded. ASTM A 514 plates are joined using (MMAW) arc welding. The evidence that welding electrode type are important parameter that must be monitored in order to produce weld joints of enhanced mechanical properties. The tensile test properties such as ultimate tensile, yield stress and strength of welded joints are investigated. From the work, following are the conclusions. CaO and SiO<sub>2</sub> are the influencing factors for tensile strength whereas CaF<sub>2</sub> does not affect. Flux with BI of 3.38 is shown maximum tensile strength of 740N/mm<sup>2</sup>. Tensile strength is improved with basicity index of flux. From the results it can be concluded that BI plays important role in the achieving even better mechanical properties. It has been also observed that mechanical properties are not affected by BI only but % age composition of flux constituents in conjunction with BI plays role in deciding the same. Tensile strength first increases then further decreases with increase of BI. It is clear from plots that the highest tensile stress occurs when welding with electrode no 5, having high basicity index (BI) of 3.38. Tensile strength value is varying with varying composition of CaO and SiO<sub>2</sub>.

Table 1: Chemical Composition of Fluxes

RunOrder	PtType	Blocks	CaO	CaF2	SiO2	MgO	Mno	TiO2	Al2O3	K2O	FeO&Bentonite	Basicity Index
1	-1	1	17.1429	22.1429	22.1429	18.5714	4	6	6	2	4	2.26904
2	-1	1	17.1429	22.1429	17.1429	23.5714	4	6	6	2	4	2.97531
3	1	1	15.0000	20.0000	15.0000	30.0000	4	6	6	2	4	3.38095
4	-1	1	17.1429	27.1429	22.1429	13.5714	4	6	6	2	4	2.26904
5	1	1	25.0000	20.0000	15.0000	20.0000	4	6	6	2	4	3.38095
6	1	1	25.0000	30.0000	15.0000	10.0000	4	6	6	2	4	3.38095
7	1	1	15.0000	30.0000	25.0000	10.0000	4	6	6	2	4	1.96774
8	-1	1	22.1429	27.1429	17.1429	13.5714	4	6	6	2	4	2.97531
9	-1	1	22.1429	22.1429	22.1429	13.5714	4	6	6	2	4	2.26904
10	0	1	19.2857	24.2857	19.2857	17.1429	4	6	6	2	4	2.63842
11	-1	1	17.1429	27.1429	17.1429	18.5714	4	6	6	2	4	2.97531
12	1	1	15.0000	30.0000	15.0000	20.0000	4	6	6	2	4	3.38095
13	1	1	25.0000	20.0000	25.0000	10.0000	4	6	6	2	4	1.96774
14	-1	1	22.1429	22.1429	17.1429	18.5714	4	6	6	2	4	2.97531
15	1	1	15.0000	20.0000	25.0000	20.0000	4	6	6	2	4	1.96774

Table 2: Tensile Strength Results

Electrode No	Basicity Index	Yield Strength In N/mm <sup>2</sup>	Ultimate Strength in N/mm <sup>2</sup>
1	2.26	443	530
2	2.97	520	610
3	3.38	625	720
4	2.26	406	490
5	3.38	646	740
6	3.38	610	700
7	1.96	486	590
8	2.97	533	620
9	2.26	491	580
10	2.63	466	550
11	2.97	550	640
12	3.38	618	710
13	1.96	478	570
14	2.97	557	650
15	1.96	442	530

## CONCLUSIONS

From the results, the following can be concluded. The high strength steel (ASTM 514) plates are joined using (MMAW) arc welding. The evidence that welding electrode type are important parameter that must be monitored in order to produce weld joints of enhanced mechanical properties. The tensile test properties such as ultimate tensile, yield stress and strength of welded joints are investigated. From the work, following are the conclusions.

- CaO and SiO<sub>2</sub> are the influencing factors for tensile strength whereas CaF<sub>2</sub> does not affect.
- Flux with BI of 3.38 is shown maximum tensile strength of 740N/mm<sup>2</sup>.
- Tensile strength is improved with basicity index of flux. From the results it can be concluded that BI plays important role in the achieving even better mechanical properties. It has been also observed that mechanical properties are not affected by BI only but % age composition of flux constituents in conjunction with BI plays role in deciding the same.

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